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A Search for Structure. Selected Essays on Science, Art and History

Cyril Stanley Smith and David Goodstein

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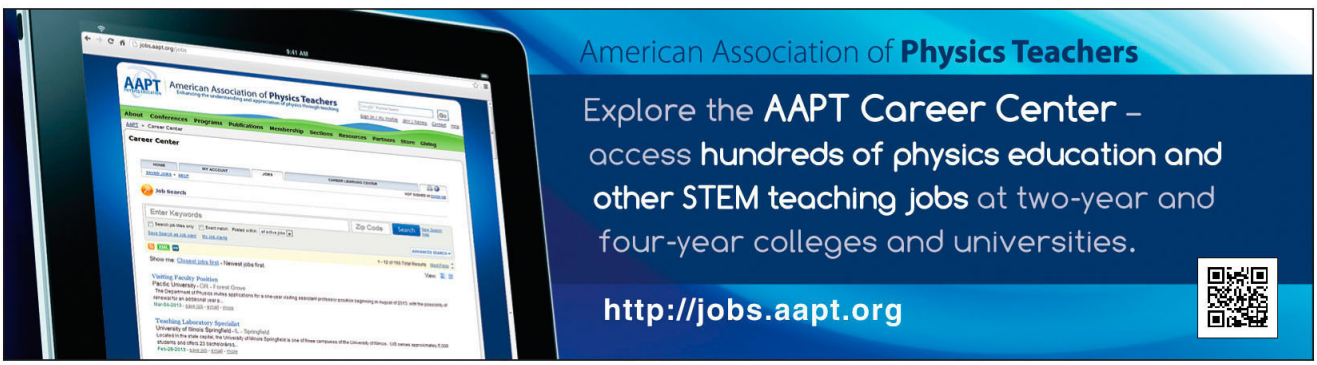

POST-USE REVIEW: Physics for Science and Engineering, Part I. Jerry B. Marion and William F. Hornyak. Saunders College Publishing, Philadelphia, 1982. 743 pp. Price: $31.95. (Reviewed by A. P. French.)

All M. I. T. undergraduates have to satisfy an "institute requirement" of two semesters of introductory physics. For a number of years the freshman sequence offered for this purpose has consisted of one semester mostly on classical mechanics and one semester largely devoted to electricity and magnetism. An advanced option, typically using Kleppner and Kolenkow, *An Introduction to Mechanics*, and Purcell's *Electricity and Magnetism*, is available to students with a strong mathematical background (typified by advanced placement in calculus); about 20% of the freshmen take this sequence. Most of the remainder, however (about 750 students per year, predominantly pre-engineering students), take the "main-line" sequence, which has often been taught with the help of such old standbys as Resnick and Halliday or Sears, Zemansky, and Young as textbooks. These have the disadvantage that many of our students have encountered them in high school and thus have an attitude of "déjà vu" if they find them being used again in the freshman course. In the academic year 1982–83 the new text by Marion and Hornyak was used; this review is a report on our experience with Part I of that text for the first semester of the course.

The choice of Marion and Hornyak was made following a survey of currently available books at this level. Besides Resnick and Sears, the list included Eisberg and Lerner; Bueche; Roller and Blum; Tipler; and Hudson and Nelson. The similarities between these books are more prominent than their differences; all are carefully and competently constructed, and Marion and Hornyak was not an obvious or clear-cut choice. We did, however, feel that the level was about right (somewhat more challenging than Sears, for example); the book seemed to have a good balance between descriptive physics and analytical treatments; we liked the placement of the calculus "appendices" at strategic places throughout the book—greatly enhancing the likelihood that they would be noticed and read; and a non-negligible consideration was the fact that the book was available in two separate volumes, thus leaving the way open for a different text to be chosen for the second semester of the course.

In using the book for a one-semester course, we knew that some topics would have to be omitted. We ended up by doing most of the basic mechanics (Chaps. 2–15) and then discussing "properties of matter" (Chaps. 16–18) and thermal physics plus kinetic theory (Chaps. 22–24).

For the most part, the presentation of subject matter in the text seemed to be well planned and effective. The one major exception was Chap. 8, on forces and potential energy. Here it seemed that the basic ideas were obscured by a preoccupation with the formal discussion of conservative fields. Another place where the presentation was unduly complicated and forbidding was in the treatment of many-particle systems and rigid bodies.

Generally speaking, the text seemed to be correct in its physics and rather free of typographical errors. The one flagrant error of physics that we noted was in the assumption that objects falling through the air are opposed by a viscous force ($\sim v$), not a hydrodynamic force ($\sim v^2$). The calculation of the terminal speed of a skydiver (Sec. 6-3) is therefore quite fallacious, even if fortuitously correct in order of magnitude.

End-of-term evaluations of the course (turned in by more than 50% of the students) rated the text to be somewhat difficult, but also somewhat dull. (It must be remembered that these students are what H. R. Crane called "captives."[1]) Informal feedback during the course of the semester told us that many students had trouble reading the text—they couldn't see the forest for the trees. Highly abbreviated "review notes," summarizing the essential theoretical features with a minimum of mathematical complication, were accordingly issued and were gratefully received. In the view of one of my colleagues this highlights a property, which he regards as educationally objectionable, of all introductory physics texts nowadays. They are all "damned, thick, square books," in the words that the Duke of Gloucester is said to have addressed to the historian Edward Gibbon.[2] No student can digest so much material, and many are bewildered. Should textbook writers return to the model set by N. H. Frank, whose *Introduction to Mechanics and Heat* was less than 400 pages and represented a full year's work in physics? At that rate of presentation one could demand that students truly master the material; with the current vogue in textbooks this is impossible. Perhaps that goes outside the scope of the present review, but it is certainly worth considering.

I should add, although I do not speak from first-hand experience, that Part II of Marion and Hornyak was used for the second semester of the introductory course at M. I. T. during 1982–83, but apparently was not deemed very successful. We have, however, decided to try Part I again for the first-semester mechanics course in 1983–84.

A. P. French received his B.A. and Ph.D. degrees in physics from Cambridge University, England. He has taught at Cambridge, at the University of South Carolina, and (since 1962) at M. I. T. His chief interest in recent years has been in curriculum development and teaching.

[1]H. R. Crane, "Experiments in Teaching Captives," Am. J. Phys. **34**, 799 (1966).
[2]Quoted in *Boswell's Life of Johnson*, Vol. II.

A Search for Structure. Selected Essays on Science, Art and History. Cyril Stanley Smith. 410 pp. MIT Press, Cambridge, MA, 1982. Price: $15.00 (paper). (Reviewed by David Goodstein.)

Cyril Stanley Smith is a distinguished metallurgist with a keen interest in the history of art, especially the decorative arts, and the history of science and technology. In *A Search for Structure*, a collection of his essays, he approaches those subjects and others with an eye and a sensibility forged (so to speak) by his special knowledge and experience.

Opening this volume, we expect to learn how subtle and unexpected properties of materials influence the objects man has fashioned and used. We are not disappointed. The

best essay in the book, "Metallurgical Footnotes to the History of Art," is along this line. It originated as the 1971 Penrose Memorial Lecture, and it is worth the price of admission. In other essays, we learn about topological constraints on the growth of aggregates, the discovery of the composition of steel (the most important scientific discovery in the history of metallurgy, Smith says), the brighter side of corrosion, and much more.

There are certain recurrent themes that seem to have captivated Smith's imagination throughout the 30-year period over which these pieces were written. One of the most important is his astute observation that playfulness and aesthetic pleasure have always been the natural mothers of inventions, only later adopted by necessity or bellicose competition. For example, metal was first used to make beads for necklaces, before it was used to make knives. Or, again, flowers were cultivated before grain. Materials were discovered by artists, then used by engineers, then studied by scientists, at least until the last hundred years or so, when scientists have become more self-conscious about discovering new things.

The idea of technology as applied science is a recent one, says Smith. Earlier, the engineer exploited the discovery of the artist. The driving force of technology, according to Smith, has been to make for the masses those things that were previously available only to the rich. Printing, casting, stamping, electroplating, celluloid, and so on were all consciously developed for that purpose. One of the most interesting stories Smith has to tell is of the long and largely unsuccessful history of attempts to reproduce expensive Chinese porcelain in Europe.

Another pervasive theme is that the properties of materials most important to us are governed by structures that are (usually) too small to be seen by the naked eye, too large to be understood in terms of individual atoms, and too complicated to be treated neatly with mathematics. They have thus, one way or another, managed to dodge the attention of science until the very recent past. But it is just these properties, governed by surface tension, aggregation, diffusion, inclusions of impurities, and the like, that give the world we have made for ourselves the form that it has.

Smith is at his best when he combines his special understanding and broad interests to explain to us, for example, how Japanese steel swords were made, and why they were the best in the world. He is not at his best—but we can forgive him the indulgence—when he sees in the structure of materials a metaphor for the structure of history. All of the essays are written in a graceful literary style, and all are illustrated with well chosen photographs (a few of which suffer for not being in color).

The volume does have some drawbacks. For me, the chief one was Smith's use of unexplained technical terms. I probably am better informed than most (I have occasionally been accused of committing solid-state physics, and I once even worked briefly in a foundry) but I often found descriptions hard to follow. (As a ground rule for this review, I had decided against heavy use of the dictionary; this book is to be read for pleasure, not for systematic instruction.) Also, after the fascinating story of the search for the secret of porcelain (and its unexpected side effects), I would have liked to have been told just what Chinese porcelain turned out to be (I presume we know, since most of what we still call China now comes from Europe). Finally, each essay should have been labeled with its date and place of publication, rather than sending the reader scurrying to the back of the book to place it chronologically in Smith's career, and to judge the intended audience.

In the end, though, none of this matters very much. We are left with the lasting impression of C. S. Smith, communing with a hundred generations of skilled craftsmen. These were men who, illiterate or not, almost never wrote about their craft, but who left behind an indelible record of what they had done, for Smith to read, and explain to us.

David L. Goodstein is Professor of Physics and Applied Physics at Caltech, where he conducts experimental research in condensed matter physics. He is also director and host of The Mechanical Universe, *a physics course being prepared for broadcast television.*

BOOKS RECEIVED

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Advances in Chemical Physics, Vol. LIV. I. Prigogine and Stuart A. Rice. 483 pp. Wiley, New York, 1983. Price: $75.00. ISBN: 0471-89570-9.

Advances in X-Ray Analysis, Vol. 26. (Proceedings of the 31st Annual Conference on Applications of X-Ray Analysis, Denver, August 1–6 1982.) Edited by Camden R. Hubbard *et al.* 473 pp. Plenum, New York, 1983. Price: $62.50. ISBN: 0-306-41370-1.

Apple II: BASIC Programs in Minutes. Stanley R. Trost. 176 pp. SYBEX, Berkeley, CA, 1983. (65 Ready-to-run Programs in New Books on Apple II, +, and *e*.) Price: $9.95. ISBN: 0-89588-121-7.

The Birth of Particle Physics. (Based on a Fermilab Symposium.) Edited by Laurie M. Brown and Lillian Hoddeson. 412 pp. Cambridge University Press, Cambridge, England, 1983. Price not given. ISBN: 0-521-24005-0.

1982 CERN School of Computing. (Proceedings held at Zinal, Valais, Switzerland 29 August–11 September 1982.) 350 pp. CERN 83-03, CERN, Genève, Switzerland, 1983. Price not given.

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Crystallography in North America. Edited by Dan McLachlan, Jr. and Jenny P. Glusker. 479 pp. American Crystallographic Assn., 1983. Price: $50.00. ISBN: 0-937140-07-4.

The Easy Guide to your Apple II. Joseph Kascmer. 144 pp. SYBEX, Berkeley, 1983. Price: $9.95 (paper). ISBN: 0-89588-122-5.

The Edge of Infinity: Where the Universe Came From and How It Will End. Paul Davies. 194 pp. Simon & Schuster, New York, 1983. Price: $6.95 (paper). ISBN: 0-671-46062-5.

Einführung in die Kosmometrie I—Negativ—dimensionale Räume. Otto Steiner. 45 pp. Braunschweig, West Germany, 1983. Printed in West Germany. Price not given. ISBN: 3-7682-1353-6.

Energy Storage and Redistribution in Molecules. Edited by Juergen Hinze. 615 pp. Plenum, New York, 1983. Price: $85.00. ISBN: 0-306-41272-1.

Evolution of the Universe. I. D. Novikov; translated by M. Basko. 176 pp. Cambridge, New York, 1983. Price: $14.95. ISBN: 0-521-24129-4.

The Foolproof Guide to SCRIPSIT Word Processing. Jeff Berner. 180 pp. SYBEX, Berkeley, 1983. Price: $11.95 (paper). ISBN: 0-89588-098-9.

Foundations of Space-Time Theories: Relativistic Physics and Philosophy of Science. Michael Friedman. 385 pp. Princeton University, Princeton, NJ, 1983. Price: $35.00. ISBN: 0-691-07239-6.

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Haphazard Reality: Half a Century of Science. Hendrik Casimir. 356 pp. Harper and Row, New York, 1983. Price: $20.00. ISBN: 0-06-015028-9.

How Energy Becomes Matter ... A First Look at the World of Particles (... with a supplement for those who would like to read further). CERN 1983. Designed and produced by Rafel Carreras. Price not given.

How the Laws of Physics Lie. Nancy Cartwright. 221 pp. Clarendon, New York, 1983. Price: $22.50, ISBN: 9-19-824700-1; $9.95 (paper), ISBN: 0-19-824704-4.

A Modern Handbook of Physics. B. M. Yavorsky and A. A. Detlaf. 712 pp. Imported, Chicago, IL, 1983. Price: $13.95. ISBN: 0-8285-2372-X.

Particles and Fields 2. Edited by Anton Z. Capri and Abdul N. Kamal. 706 pp. Plenum, New York, 1983. Price: $97.50. ISBN: 0-306-41162-8.

Order and Surprise. Martin Gardner. 396 pp. PROMETHEUS, Buffalo, NY, 1983. Price: $19.95. ISBN: 0-87975-219-X.

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